is often moist, making it a threat to HEPA filters.]

The first line of defense against duct and filter fires is development and enforcement of safe operating practices in the contained and operating spaces they serve. This means eliminating one or more of the basic fire elements—fuel, ignition source, or oxygen. It also includes controlling the kinds and quantities of combustible liquids and gases in contained spaces; controlling the hot plates, burners, furnaces, and other sources of heat or flame; and sometimes, for totally contained spaces such as gloveboxes or hot cells, inerting the box or cell environment with nitrogen, argon, carbon dioxide, or other gases. In addition, safe operating practices include (1) development and rehearsal of preplanned fire- and damage-control procedures in the contained and occupied spaces of the building and (2) development of means for rapidly detecting and suppressing a fire.

Conventional fire protection practices, such as the provision of fire dampers in ducts where they pass through a firewall or floor, have been sometimes ignored or discounted in the design of nuclear ventilation and air cleaning systems because it was assumed they are not needed. The established fire protection practices cited above, however, should not be omitted. In most cases, customary fire protection design practices should be followed in the design of air conditioning and ventilation facilities for “cold” (Tertiary Confinement Zone) regions of the building. The NRC requires the use of these conventional fire protection practices in commercial nuclear power plants, with special adaptations as necessary to resolve any conflicting commercial/nuclear requirements and practices.

2.8.3 POWER AND EQUIPMENT OUTAGE

The design for emergencies must plan for the probable occurrence of power and equipment (particularly fan) failures. Such failures, if not properly planned for, can result in a contamination hazard to the public or to operating personnel, particularly in buildings with zone ventilation where airflow must be maintained to preserve pressure gradients between zones and to prevent back-flow of contaminated air to occupied spaces. Possible emergency measures include redundant fans, redundant fan motors (served from independent power sources), and alternate power supplies (e.g., a steam turbine or emergency Class 1E diesel-electric generator). Where continuous airflow must be maintained, facilities for rapid automatic switching to an alternate fan, power supply, or emergency source, or to a standby air cleaning unit, are essential. However, if brief interruptions of flow can be tolerated, manual switching may be permissible at less expense. In any event, visible and audible alarms should be provided both locally and at a central control station to signal the operator when a malfunction has occurred. In addition, indicator lights to show the operational status of fans and controls in the system should be provided in the Control Room.

2.9 AIR SAMPLING

Air samples often are required to be taken from the plant unit vent stack(s) or other locations downstream of the filters to monitor the amount of radioactive material being released to the atmosphere. If the sampling system is not properly designed, amounts of released radioactive or toxic material may be underestimated. The sampling element or the sampling line itself is most frequently at fault. If the sampling line is too long or too small in diameter (relative to flow velocity in the line), it may act as a diffusion tube to remove small particles or as an inertial separator to capture large particles before they can reach the counting and recording equipment. Sharp-angle bends, valves, and other flow restrictions must be minimized to avoid losses due to inertia, impaction, and impingement. Horizontal runs must be minimized to avoid gravitational settling. Conduit diameter must be large enough and sufficiently consistent with flow velocity to minimize the diffusion losses and turbulence that can cause migration of particles to the conduit walls, where they may be captured (turbulence in sampling lines can take place at a Reynolds number of 1,200 or lower).[25] The optimum sampling line diameter, considering both line losses and practical limitations on line sizes, can be found from the following equation .[26]

$$d = \frac{Q}{150} \quad \text{(metric)} \qquad d = \frac{Q}{9.15} \quad \text{(English)} \qquad (2.4)$$

where

d = diameter of sampling conduit, cm(or in.)

Q = sampling rate, cm^3/sec (or $in.^3$/sec)

Sampling nozzles should be sized for isokinetic inlet velocity. Sampling lines should be vertical, where practicable, and should be as short as possible between the collector nozzle and counting instruments (some stack sampling instruments are located on the stack at the same level as the sampling point). Sample lines should be compatible with the constituents of the effluent stream (customarily stainless steel or copper in nuclear applications). They must be clean and smooth on the inside and should be detachable to permit occasional field cleaning. Oil and moisture on the inner surfaces of the sample lines will trap particles and give false readings. Cleaning by procedures that meet the requirements of ASTM A380[27] is recommended.

Sampling elements should be of the isokinetic type and should consist of multiple arrays of sensing points so that an accurate, representative sample is obtained for the measuring devices. Variable flow devices have been marketed to allow isokinetic sampling in streams in which duct velocities are changing.

2.10 REFERENCES

1. 10 CFR Part 20, "Standards for Protection Against Radiation," U.S. Nuclear Regulatory Commission.
2. 10 CFR Part 100, "Reactor Site Criteria," U.S. Nuclear Regulatory Commission.
3. 10 CFR Part 50, "Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission.
4. Oak Ridge National Laboratory, "Design Criteria for Radiochemical Plants and Laboratories," Procedures and Practices for Radiation Protection-Health Physics Manual, Appendix A-11, Jan. 8, 1974.
5. USNRC (U.S. Nuclear Regulatory Commission), "General Design Guide for Ventilation Systems of Plutonium Processing and Fuel Fabrication Plants," Regulatory Guide 3.12 , Washington, DC.
6. American Conference of Governmental Industrial Hygienists, TLVs—Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment, Cincinnati, OH (issued annually).
7. IAEA (International Atomic Energy Agency), "Report of International Atomic Energy Agency (IAEA) Symposium on Airborne Radioactivity," Nucleonics Week, 8(9), July 20, 1966.
8. Harrington, R. E., "Fine Particulates—The Misunderstood Air Pollutant," J. Air Pollut. Control Assoc. 24(10), October 1974, pp. 927-929.
9. Whitby, K.T., et.al., 1957, "The ASHAE Air-Borne Dust Survey," Heat, Piping Air Cond., November 1957, pp. 185-192.
10. Austin, P.R., "Personnel Emissions in Laminar-Flow Clean Rooms," Contam. Control. 5(7), July 19, 1966.
11. Burchsted, C.A., "Environmental Properties and Installation Requirements for HEPA Filters," Proc. Symp. Treat. Airborne Radioact. Wastes, International Atomic Energy Agency, Vienna, 1968.
12. First, M.W., "Performance of Absolute Filters at Temperatures from Ambient to 1000º F," Proc. 12th AEC Air Clean. Conf., USAEC Report CONF-720823, January 1973.
13. ANSI (American National Standards Institute, Protective Coatings (Paints) for the Nuclear Industrial, ANSI N512, New York, 1975.
14. First, M.W., and L., Silverman, "Cost and Effectiveness of Air Cleaning Systems," Nucl. Saf. 4(1), September 1962, pp. 61-66.
15. ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers), Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter, ASHRAE 52, New York, current issue.
16. Air Conditioning, Heating and Refrigeration News, July 30, 1967, p. 28.
17. USNRC (U.S. Nuclear Regulatory Commission), "Design, Testing, and